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A STUDY ON ENGINE CAPACITY & FUEL ECONOMY IN THE INDIAN PASSENGER CARS COMPARED TO THE US PASSENGER CARS

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ABSTRACT

This Engine Capacity is one of the key parameters impacting the Fuel Economy of automobiles. As the volume of the Engine capacity increases, the power output also increases. But, increased capacity eventually reduces mileage. The Fuel Economy of a car is inversely proportional to the engine capacity in a conventional design. The manufacturers keep upgrading the engines and strike a balance between power and Fuel Economy to meet customer expectations and Fuel Economy and emission norms. This Article analyses the relationship between Engine Capacity and the Fuel Economy in Indian Passenger Cars and identifies the need for a standardized process for measuring Fuel Economy.

KEYWORDS: Engine Capacity, Fuel Economy, Mileage & Indian Passenger Cars

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Original Article

INTRODUCTION

Vehicles are one of the contributors to air pollution and there is a need to reduce vehicular emissions on a continuous basis. The emission norms have been progressively tightened, and the automotive industry responded by developing new engines, new technologies and after treatment devices such as catalysts. In the early stages, Carbon Monoxide, Hydrocarbons and Oxides of Nitrogen were identified as harmful pollutants and targeted for control. When global warming was identified as a serious issue, Carbon Dioxide was identified as one of the contributors. In the case of automobiles, be it cars or two-wheelers or any other vehicle, CO_2 is a direct function of the fuel consumed. Indian regulatory authorities have proposed Fuel Economy norms in two phases in India – 2017-18 and 2022-23. Among other things, Engine Capacity is one of the parameters impacting the Fuel Economy of automobiles. Engine design and technology are key determinants of the Fuel Economy of an automobile or light truck[1]. Several innovations are taking place to improve the Fuel Economy. However, acceptance of new technology will be judged based on the cost-benefit trade-off[2]. This Article analyses the relationship between Engine Capacity and the Fuel Economy based on data published by the Society of Indian Automobile Manufacturers and US Fuel Economy Guide (Model Year 2019) published by the U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE).

Engine Capacity or Engine Displacement is the volume swept by the piston, as it moves from Bottom Dead Center (BDC) to Top Dead Center (TDC) [3]. The Engine Capacity is expressed as Litre or Cubic Centimetres. It is the combined capacity for all cylinders of the engine added together, when it finishes its one cycle. The volume of an engine can be obtained by using the formula[4]:

$V = \pi d^2 h/4 \times n$

[V - Volume, d - Bore diameter, h – Length of stroke, n - Number of cylinders]

When the volume of the cylinders goes up, the power output increases. But this reduces the Fuel Economy. The Fuel Economy of a vehicle is inversely proportional to the engine capacity in a conventional design. The automobile manufacturers have to strike a balance between power and Fuel Economy and meet the customer expectations and emission norms.

Society of Indian Automobile Manufacturers has been publishing the Fuel Efficiency Data for various models of Passenger Vehicles manufactured in India. This article analyses the fuel efficiency declarations published in 2011 and 2019 by SIAM[5]. A brief analysis has also been done on US Passenger Cars based on US Fuel Economy Guide (Model Year 2019) published by the U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE)[5]

PRESENT STUDY

The present study covers the specifications of Passenger cars – both Petrol and Diesel and the Fuel Economy of the vehicle models listed in the FE Declarations. The data provided in the 1st SIAM FE Declaration published in Jan 2011 and the 9th SIAM FE Declaration 2017-18 published in March 2019 have been considered for the analysis. For US vehicles, the data provided in Fuel Economy Guide (2019)6. Fuel Economy of Indian vehicles has been converted to Miles per Gallon (US) or MPG for easier comparison.

Analysis & Key Observations

The analysis of Fuel Economy Data of Indian Passenger Cars provides the following information:

Table 1: Passenger Cars in India – Engine Capacity and Fuel Economy

Passenger Cars		Engine Capacity			Declared Fuel Economy in MPG		
	No of Models	Average CC	Minimum CC	Maximum CC	Average	Minimum	Maximum
Diesel							
2019	238	1947	625	4461	42.7	22.6	66.8
2011	127	1992	702	3200	38.5	20.5	55.5
Petrol							
2019	201	1773	624	4951	37	18.4	109.4
2011	143	2185	624	6208	31.7	16	56.3

Key Observations (Table 1)

- No. of Diesel models dropped significantly, while no. of petrol models increased
- Average CC for Petrol has dropped in 2019 while the drop in CC for Diesel models is not significant
- FE has gone up for Diesel and Petrol models between these two periods, improvement in Petrol FE is higher than Diesel
- Max CC has dropped for both Petrol and Diesel, while Minimum has gone up for both.

Table 2: Segment-Wise Analysis – Engine Capacity & Fuel Economy (2019) Indian Cars

Engine CC	2019 No of Models		2019 Fuel Economy MPG		*Co-efficient of co-Relation*	
	Petrol	Diesel	Petrol	Diesel	Petrol	Diesel
Up to 1200	73	11	45.2	53.2	-0.5	0.2
1200-1600	47	93	39.5	51.8	0.0	-0.5
1600-2000	45	42	32	39.5	-0.3	-0.3
2000-2400	1	46	28.2	35.7	-	-0.1
2400-2800	10	21	25	32.1	-0.9	0.0
Above 2800	25	25	22.6	31.2	-0.4	-0.4
Total	**201**	**238**	**37**	**42.7**	**-0.7**	**-0.8**

Key Observations (Table 2)

- 82% of Petrol vehicles are 2000 CC or less; 81% of diesel vehicles are 2400 CC or less
- For Diesel vehicles, FE is dropping significantly in 1600 CC -2000CC segment. This may be due to the reason that in this segment, almost all the vehicles are SUV's and have substantially greater weight. The Engine CC of all the vehicles under this segment is 1950 CC or above.
- While it is clear that Engine CC and Fuel Economy have negative co-relation, the relationship at segment level is not very strong in most of the segments. This may be due to the fact that for the same Engine CC, presence of multiple FE levels for different models. This is evidenced by the following example:

Table 3: Analysis – Fuel Economy for Same Engine Capacity (2019)

Sl. No.	Manufacturer	Model	Weight	Engine CC	Fuel	MPG
1	Maruti Suzuki	Ignis	960	1248	Diesel	63.1
2	Maruti Suzuki	Ignis AMT	960	1248	Diesel	63.1
3	Maruti Suzuki	Baleno	985	1248	Diesel	64.5
4	Maruti Suzuki	Dzire	985	1248	Diesel	66.8
5	Maruti Suzuki	Dzire AMT	990	1248	Diesel	66.8
6	Maruti Suzuki	Swift	1060	1248	Diesel	59.3
7	Maruti Suzuki	Dzire Tour	1070	1248	Diesel	62.6
8	Maruti Suzuki	Ciaz SHVS	1135	1248	Diesel	66.1
9	Tata Motors	Bolt 75PS	1154	1248	Diesel	51.1
10	Tata Motors	Zest MT 75PS	1154	1248	Diesel	51.1
11	Tata Motors	Zest MT 90PS	1170	1248	Diesel	47.3
12	Tata Motors	Zest AMT 90PS	1185	1248	Diesel	47.3
13	Maruti Suzuki	Brezza	1195	1248	Diesel	57.2
14	Maruti Suzuki	S-cross 1.3L	1205	1248	Diesel	55.8
15	Maruti Suzuki	Ertiga SHVS	1265	1248	Diesel	57.6

It is also noticed in the Table 3, for the same Engine Capacity, the Fuel Economy goes down with the increase in weight.

Table 4: Segment-Wise Analysis of US Passenger Vehicles (2019)

Engine CC	No of Models		Fuel Economy in MPG	
	2019		2019	
	Petrol	Diesel	Petrol	Diesel
upto 1200	10	0	35.0	-
1200-1600	229	12	31.3	33.3
1600-2000	535	12	26.7	32.7
2000-2400	107	0	24.8	-

Table 4: Contd.,				
2400-2800	148	10	25.1	21.8
Above 2800	1088	14	19.6	23.7
Total	**2117**	**48**	**23.4**	**28.0**

Key Observations (Table 4)

Petrol Vehicles

51% of the models have Engine Capacity above 2800 CC and 89% above 1600 CC

The no. of Models Above 2800 CC is just 25 in India (1088 in the US)

Fuel Economy for the same segment is higher in India compared to the US

Diesel Vehicles

No. of models are far less compared to Petrol vehicles/India Diesel Models

Fuel Economy of Indian Diesel vehicles are 50% higher than US Diesel Models

Further, drill-down analysis is done on US data to compare the Fuel Economy of US Vehicles vs. Indian Vehicles. The following provides the analysis:

Table 5: Analysis of Fuel Economy - US Petrol Vehicles vs. Indian Petrol Vehicles

Fuel Economy in Petrol Vehicles - US (2019)					Indian Vehicles (2019)	
Engine CC	No of Models	TEST Fuel Economy in MPG			No of Models	Declared Fuel Economy in MPG
		Combined	City	Highway		
Up to 1200	10	35.0	32.8	38.8	73	45.2
1200-1600	229	31.3	28.8	35.4	47	39.5
1600-2000	535	26.7	23.8	31.4	45	32.0
2000-2400	107	24.8	22.1	29.4	1	28.2
2400-2800	148	25.1	22.9	28.7	10	25.0
Above 2800	1088	19.6	17.1	24.0	25	22.6
Total	**2117**	**23.4**	**20.8**	**27.8**	**201**	**37.0**

Table 6: Analysis of Fuel Economy - US Diesel Vehicles vs. Indian Petrol Vehicles

Fuel Economy in Diesel Vehicles - US (2019)					Indian Vehicles (2019)	
Engine CC	No of Models	TEST Fuel Economy in MPG			No of Models	Declared Fuel Economy in MPG
		Combined	City	Highway		
Up to 1200	0	-	-	-	11	53.2
1200-1600	12	33.3	28.8	41.2	93	51.8
1600-2000	12	32.7	29.2	37.8	42	39.5
2000-2400	0	-	-	-	46	35.7
2400-2800	10	21.8	19.2	27.6	21	32.1
Above 2800	14	23.7	21.4	27.6	25	31.2
Total	**48**	**28**	**24.8**	**33.5**	**238**	**42.7**

Key Observations (Table 5 & 6)

Table 5 & 6 shows, the Fuel Economy declared by Indian Vehicle Manufactures are higher than even the Highway Mileage of US vehicles. This may be due to either the process of measuring the Fuel Economy is not consistent or standardized, or it could be due to the design of the vehicle models.

Table 7: Impact on Fuel Economy Due to Increase of 100 CC in Engine Capacity

Petrol Vehicles				**KeyObservations**
Year	**Engine CC**	**FE in MPG**	**Fall in FE in MPG**	
2019	1600	38.551		1. FE has improved for the same Engine CC between 2011 &2019. 2. Fall in FE is significant for the increase in Engine CC between 2011 & 2019
	1500	39.641	**1.09**	
2011	1600	35.109		
	1500	35.679	**0.57**	
Diesel Vehicles				
Year	**Engine CC**	**FE in MPG**	**Fall in FE in MPG**	1. FE has improved for the same Engine CC between 2011 &2019. 2. Fall in FE is not so significant for the increase in Engine CC between 2011 & 2019
2019	1600	47.336		
	1500	48.676	**1.34**	
2011	1600	43.47		
	1500	44.72	**1.25**	
Petrol Vehicles: (US)				
Year	**Engine CC**	**FE in MPG**	**Fall in FE in MPG**	1. FE in Indian vehicle for the same Engine CC is more compared to that of US. 2. Fall in FE is not so significant for the increase in Engine CC between 2011 & 2019
2019	1600	28.10		
	1500	28.42	**0.33**	
2011	1600	30.57		
	1500	30.88	**0.31**	

Relationship between Engine Capacity & Fuel Economy in India & US Passenger Cars is given in Figure 1 and Figure 2

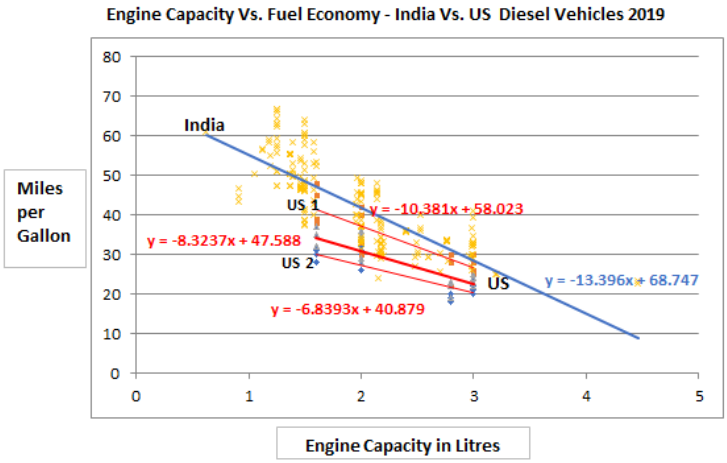

Figure 1

(US – Combined, US1 – Highway & US2 City Fuel Economy; India – Fuel Economy of Indian vehicles)

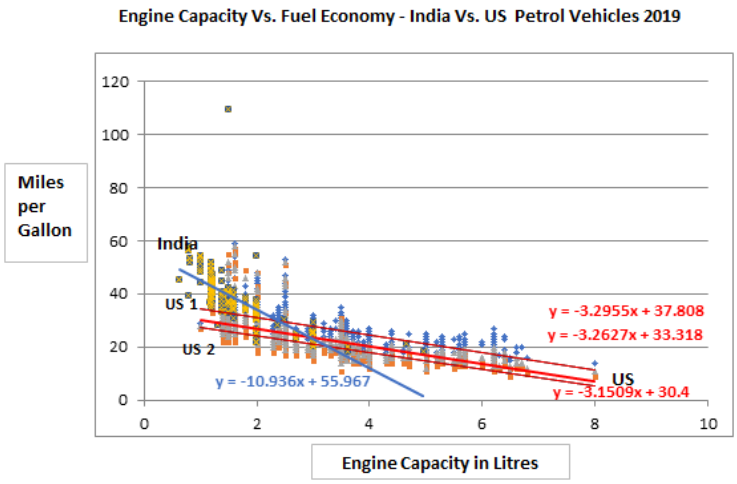

Figure 2

(US – Combined, US1 – Highway & US2 City Fuel Economy; India – Fuel economy of Indian vehicles)

Note: The number of Petrol and Diesel vehicles in >2800 CC segment in India is very low compared to US. (Refer: Table 4, 5 & 6)

Is Fuel Economy in the Indian vehicles Really Better than the US Vehicles?

In the US, Fuel Economy is computed by following a series of tests specified under the US regulatory. Automobile manufacturers test their own vehicles and report the results to the US Environment Protection Agency (EPA). About 15%–20% of them are confirmed through their own tests at the National Vehicles and Fuel Emissions Laboratory. Fuel Economy is given for City, Highway, and Combined. From 2008 onwards, three additional tests are used to adjust the city and highway estimates to account for higher speeds, air conditioning use, and colder temperatures[7]. Final Fuel Economy figures are adjusted downwards by 10% for City driving and 22% in Highway mileage to reflect the differential between what happens in a lab and on an actual environment.

In India, the Society of Automotive Manufacturers (SIAM) has published the Fuel Economy Data for 2017-18, but the procedure for testing the Fuel Economy is not available on the website.

One important difference is that almost all the cars in the US employ Automatic transmission. Also, in the US, tests are carried out to take into account the load due to the use of air conditioners, which also is known to cause a drop in Fuel Economy. According to a study in the US, a 400-Watts load on a conventional engine can decrease the fuel economy by about 0.4 km/L (1 mpg) [8]. In the case of Indian cars, the majority of cars use manual transmission, though Automatic Transmission is now being offered in many models. SIAM has not provided the test procedure adopted for the Fuel Economy Data declared on its website. However, for emission regulation, a test procedure has been prescribed by the Ministry of Road Transport and Highways[9]. Fuel Economy can be computed, when the car is driven on the driving cycle for measuring emissions. For this purpose, the Modified Indian Driving Cycle (MIDC) is used since 2000, which is based on Europe's New European Driving Cycle (NEDC). It is primarily based on NEDC, but with max speed 90 kph instead of 120 kph. This cycle has a low average speed of 32.5 km/hour, no harsh accelerations or braking and air conditioners are not operated. A comparison of Indian driving cycles (IDC and MIDC) with others in the world shows that Indian cycles employ lower speeds in comparison[10]. According to another study published in 2005, IDC does not represent the real-

world driving and also confirmed that it may lead to underestimation of the emission rates[11].Hence, further research is needed to identify the reason for the high Fuel Economy in Indian vehicles compared to the US.

LIMITATIONS

The analysis is limited to the Petrol/Diesel models given in the data published in the declarations. Also, this analysis has not considered the volume of vehicles produced under each model. CNG/LPG fuel model cars have not been considered for this exercise.

CONCLUSIONS

Engine capacity and the fuel consumption are related, but the increase in Fuel Consumption is not directly proportionate to the Engine Capacity. Models with the same Engine Capacity may still have different Fuel Economy rates. Besides weight, other factors like aerodynamics, transmission, induction, auxiliaries, driving patterns, etc. could also impact the Fuel Economy for the same Engine Capacity. According to a leading Automobile Manufacturer, emissions tend to increase as the engine size becomes smaller than an optimal level[12]. The manufacturers keep upgrading the engines and strike a balance between power and mileage to achieve both performance and efficiency to meet the compliance norms for emission control. There is a need to standardize the process for measuring fuel economy, so that there is a meaningful comparison. This would not only help the customer but also measure the emission data properly, as emission is based on Fuel Economy.

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